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An overview of biomass energy utilization in Vojvodina

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ABSTRACT

The Autonomous Province of Vojvodina is an autonomous province in Serbia. It is located in the northern part of the country, in the Pannonia plain. Vojvodina is an energy-deficient province. Energy plays a pivotal role in socio-economic development by raising the standard of living. Biomass has been used by mankind as an energy source for thousands of years. Traditional fuels like firewood, dung and crop residues currently contribute a major share in meeting the everyday energy requirements of rural and low-income urban households in Vojvodina. Contribution of the renewable energy sources in the total consumption of energy in Vojvidina is less than 1%, i.e. it amounts to 280 KWh/year. Production of biodiesel in the year 2008 was 0.07 million tons, what is for 133% higher with respect to the production in the year 2007 (0.03 million tons). In Vojvodina, as the raw materials for bioethanol production are seen primarily sugar beet, corn, wheat surpluses, potato surpluses and waste potato, as well as the raw materials intended for these purposes grown on the uncultivated soils, such as hybrid broomcorn, Jerusalem artichoke and triticale. With introduction of new technologies for cultivation and collecting of biomass production of the electrical energy could be raised to 6.4 GWh/m^2 year, what, with retention of the contemporary consumption, would represent the significant 9% of the total consumption in the province. According to programme of realisation of energy strategy of Vojvodina/Serbia in the field of the renewable energy sources for to period till the year 2010 and its completion, till the year 2015, in Vojvodina could be created conditions for the employment of about 24,000 workers, i.e. 4000 employed for maintenance of the newly constructed plants, 17,000 employed on designing and manufacturing of plants and 3000 employed in auxiliary activities.

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Contents

1. Introduction

The Autonomous Province of Vojvodina is an autonomous province in Serbia, containing about 27% of its total population

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according to the 2002 Census. It is located in the northern part of the country, in the Pannonia plain. Vojvodina is an energy-deficient province. The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. The oil import bill is a serious strain on the country's economy and has been deteriorating the balance of payment situation. The country has become increasingly more dependent on fossil fuels and its energetic security hangs on the fragile supply of imported oil that is subject to disruptions and price volatility [1,2].

1.1. Energy and biomass

Energy is an integral part of society and plays a pivotal role in its socio-economic development by raising the standard of living and the quality of life. The state of economic development of any region can be assessed from the pattern and consumption quality of its energy. Energy demand increases as the economy grows bringing along a change in the consumption pattern, which in turn varies with the source and availability of its energy, conversion loss and end use efficiency [3].

Through the different stages of development, mankind has experimented with various sources of energy ranging from wood, coal, oil and petroleum to nuclear power. In recent years, public and political sensitivities to environmental issues and energy security have led to the promotion of renewable energy resources. Biomass is one such resource that could play a substantial role in a more diverse and sustainable energy mix. The energy obtained from biomass is a form of renewable energy and, in principle, utilization this energy does not add "new" carbon dioxide, a major greenhouse gas, to the atmosphere, in contrast to fossil fuels. Defining precisely, the organic matter derived from biological organisms (plants and animals) is called biomass. Biomass has been used as an energy source for thousands of years, ever since humans started burning wood to cook food or to keep them warm. As per an estimate, globally photosynthesis produces some 220 billion tons of dry biomass each year with 1% conversion efficiency [3–6].

1.2. Biomass categorization

Biomass can be broadly categorized as woody, non-woody biomass and as animal wastes. Woody biomass comprises forests, agro-industrial plantations, bush trees, urban trees and farm trees. Woody biomass is generally a high-valued commodity and has diverse uses such as timber, raw material for pulp and paper industry, pencil and matchstick industries and cooking fuel. Non-woody biomass comprises crop residues like straw, leaves and plant stems, processing residues like saw dust, bagasse, nutshells and husks and domestic wastes (food, rubbish and sewage). Animal waste constitutes the waste from animal husbandry [3].

1.3. Using biomass for energy

The main processes by which energy may be obtained from biomass include direct combustion, pyrolysis, gasification, hydro gasification, liquefaction, anaerobic digestion, alcoholic fermentation and trans-esterification. Each technology has its own advantages, depending on the biomass source and the form of energy needed [5].

Electricity generation is considered the most suitable way for commercial exploitation of biomass, by virtue of the high value of electricity. Biomass based electricity schemes already provide over 9 GWe of worldwide generation capacity. Cogeneration technology, based on multiple and sequential use of a fuel for generation of steam and power, is a viable option for power generation in process industries such as sugar, paper and rice mills, among others. Sugar beet can provide a significant amount of biomass for electricity production, and its potential becomes much higher with advanced cogeneration technologies [7].

The energy supply from municipal and animal wastes has multiple advantages in that it not only eliminates the environmental pollution but also saves on fuel cost in the manufacturing/processing industries. Energy production from food wastes or food processing wastes, especially from waste edible oils, seems to be attractive based on bioresource sustainability, environmental protection and economic consideration. Biodiesel, produced from new and used vegetable oils and animal fats, is attractive for several reasons. It is a natural, renewable resource and a cleaner-burning diesel replacement fuel. Just like petroleum diesel, biodiesel operates in compression–ignition engines or diesel engines. Biodiesel has physical properties very similar to conventional diesel. Biodiesel is better than diesel fuel in terms of sulphur content, flash point, aromatics content and biodegradability. Depending upon the climate and soil conditions, different countries are looking for different types of vegetable oils as substitutes for diesel fuels. For example, soybean oil in the US, rapeseed and sunflower oils in Europe, palm oil in Southeast Asia (mainly Malaysia and Indonesia) and coconut oil in the Philippines are being considered. Besides, some species of plants yielding non-edible oils, e.g. jatropha and pongamia, may play a significant role in providing resources [8–11].

Animal dung is a potentially large biomass resource and dried dung has the same energy content as wood. When burned for heat, the efficiency is only about 10%. About 150 million tons (dry) of bovine dung are used as fuel each year across the globe. The efficiency of conversion of animal residues could be raised to 60% by producing biogas through anaerobic digestion. Biogas systems offer multiple benefits. For cooking and other household thermal tasks, it is simple and reasonably efficient to use the gas directly in conventional low-pressure gas burners. Biogas can provide lighting when used in mantle lamps. The digester effluent adds economic value by providing valuable fertilizer. It leads to environment protection as well as to improving of sanitary conditions in rural areas. Biogas plants are widely in operation in China, India, Sudan, Taiwan, etc. [3,9].

Plant materials that are particularly rich in starches and sugars such as sugar beet, wheat, etc., can be fermented into bioethanol. Alternatively, methanol can be produced by the distillation of biomass, which contains considerable cellulose such as wood and residues from sugar beet. Both these alcohols can be used to fuel vehicles and machinery, and can be mixed with gasoline to make a gasoline/alcohol blend. Brazil's National Fuel Alcohol Program was launched in 1975, based on an initial strategy of substituting gasoline in the internal combustion engines of light vehicles, mainly Otto cycle. Phased in through blends initially at small percentages, it has now reached 24%, with no need for any technical modifications to vehicles [12,13].

2. Biomass energy utilization in Vojvodina

Contribution of renewable enargy sources in total energy consumption of Vojvodina contemporary amounts to less than 1%, apropos 280 GWh/year [14]. By combining of methods of introduction of new and renewablew sources, systematic application of methods for increasing energetic efficacy, as well as of introduction of the new technologies, percentage of contribution of the non-conventional energy sources in Vojvodina could be increased to as much as 20% [15,16].

2.1. Biodiesel

Production of biodiesel in the year 2008 was 0.07 million tons (0.07 Mtoe), (1 Mtoe = 41.868×10^{15} J), what was 133% more than

Table 1
Energetic potentials of the most significant plant species in Vojvodina.

Plant species	Average farm (km^2)	Large farms (km^2)	Small- and medium-sized farms (km^2)	Biomass that could be collected (KT)		For energetic purposes (KT)	
				Large farms	Small- and medium-sized farms	Large farms	Small- and medium-sized farms
Wheat	33.6	14.2	19.4	300	340	285	305
Rye	0.115	0.042	0.073	1	1.3	1	1.2
Barley	6	2.9	3.1	60	55	57	50
Corn	62.7	11.4	51.3	124	670	120	610
Soy	11.15	5.6	5.55	120	115	120	115
Oil rape	1.54	1.23	0.31	30	8	30	8
		Total		635	1189 1824	613	1089 1702

in the year 2007 (0.03 million tons). The available biodiesel quantity for final consumption was 0.069 million tons (0.07 Mtoe) or for 138% more than in the year 2007; of this quantity, traffic vehicles spent 0.042 million tons (0.042 Mtoe) or for 133% more than in the year 2007 (0.018 million tons), and the agriculture 0.027 million tons (0.027 Mtoe) or for 146% more than in the year 2007 (0.011 million tons).

2.2. Solid biomass

Solid biomass (agricultural residues) represents, for now, the most significant potential in Vojvodina. Table 1 shows the energetic potential of the most significant plants species in Vojvodina. Besides plant residues yields, technical ripeness of their collection and other uses were taken in account, as well. Because the technologies of production and collecting of biomass for large, medium and small farms differ, the results were discussed separately. Medium and small farms are those, whose aral soil acreage amounts to up to 2 km^2.

The results show that over 90% of total biomass quantity that could be obtained on the large-, medium- and small-sized farms could be applied for the energetic purposes. In Vojvodina, as the raw materials for bioethanol production for fuel primarily are observed sugar- (sugar beet and starchy (corn, whear surplusses, potato surplusses or waste potato) raw materials, and besides that, specialy designed raw materials planted on the non-cultivated soils (hybrid broomcorn, Jerusalem artichoke–topinambour and triticale). Estimation are that Vojvodina all ready for a longer period of time lielises yearly surplusses of cereal grains of about one million tons (at most corn, and after it, whear) that could be applied for fuel bioethanol production. Besides that, estimations indicate that in Vojvodina exist about 100,000 ha of non-cultivated soils that could be planted with cultures especially for the bioethanol production (broomcorn, Jerusalem atrichoke). In order to realise economically feasible production from husbandry plants, the indispensable prerequisite is the complete utilization of bioethanol production by-products, first of all of spent grains with their consumption for feeding purposes. The economic feasibility of the procedures depends on the applied process technology and of the appied microroganisms, their growth and adaptation on process conditions as well. In that respect, modern procedures that are more efficient and energetically more convenient by far should be favoured, especially for fermentation, distillation and dehydratation of bioethanol.

2.3. Biogas

Economically feasible biogas production is possible to perform only on larger farms. Numbers of bovine and swine animals on larger farms in Vojvodina, as well as numbers of such farms, are shown in the Table 2.

The main reason because of which agricultural husbandries in Vojvodina/Serbia do not produce and apply biogas is the lack of corresponding laws and concomitant regulations, low price of electrical energy and indolence for ecological harms, i.e. for possible benefits from production and using of biogas. The Great Channel of Backa is a drastic example—black point on the ecological map of the World. Its section near city of Vrbas is the most polluted water course in Europe. There are located, on the distances of some 8–10 km, leather factory, meat industry, open sewages of the two towns with about 70,000 inhabitants each, animal farm with 4000 sows, meat-, oil-, sugar-, pasta processing factories. Their waste waters and liquid manure from the farm are disposed into non-isolated lagoons or directly into the channel, in spite of the fact that they represent almost ideal raw material for biogas production, Corn, as the co substrate from primary agricultural production, on that location can be assured in practically limitless quantities.

2.4. Electric energy from biomass

Yearly production of electric energy from the biomass could cover less than 5% of the actual consumption [17]. With introduction of new technologies for production and processing of biomass, electric energy production could be increased to 6.4 GWh/m^2 year, what could represent, keeping the contemporary consumption level, the significant 9% of the total electric energy consumption in the province.

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Table 2
Number and size of farms with their possible biogas production possibilities in Vojvodina.

Size of swine farms (number of animals)	Number of farms	Possible biogas production (m^3/m^2 year)	Size of bovine farms (number of animals)	Number of farms	Possible biogas production (m^3/m^2 year)
600	13	26,650	700	3	5,550
1000	3	11,300	1,000	2	4,750
2600	2	17,650	2,000	5	29,100
Total	18	55,600		10	39,400

what could, with keeping of contemporary level of consumption, mean the considerable 9% of the total consumption in the province. The highest reserves are in the use of corn stalks and fast-growing plants, primarily of forests, i.e. of poplars. For the use of corn stalks, a new technology of its collection has to be developed, as well as the accompanying technology of its storage. Considerably higher biomass-based electric energy production could be realised in the designated thermo-electric plants. Three thermo-electric plants having the installed powers of 15 MWe (10–15 MWe are considered to be optimal sizes), could produce 320 MWh of electric energy per year, using some 250,000 tons of straw. Nevertheless, a new approach in the EU implies that such electric plants should not have higher power than 10 MW.

3. Plans and strategies to promote biomass use in Vojvodina

Autonomous Province of Vojvodina/Republic of Serbia, like other countries of the Western Balkans, which are interested to the affiliation in the EU, has ratified the Memorandum of Understanding on the Regional Energy Market in South East Europe and its Integration into the European Community Internal Energy Market. In such a way it has accepted the obligation of following the EU policies and programmes.

The region of South-eastern Europe represents a geographical and historic whole, with the trend of gradual acceptance of certain countries to the European Union. In that respect, it is necessary to define and observe the state of sustainable development in all four subsystems of sustainable development in all concerned countries [2].

Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market foresees that electric energy share obtained from the renewable sources should reach 22.1% of total quantity of energy from the renewable sources. The aim is for realisation of this obligation, to select the best possible solutions for electric energy production, with application of biomass by cogeneration, i.e. to help the defining of national strategies and their realisation programmes. Besides the clearly defined country's obligation, the goal is the expansion of electric energy production by using of domestic material resources, with lowering of dependences on imports and increasing the employment of population.

According to the programme of realisation of energetic strategy of Vojvodina/Serbia in scopes of the renewable energy sources for the period up to the year 2010 and its further realisation up to the year 2015, conditions for the employment of 24,000 persons would be created. These employees would include 4000 persons for the maintenance of newly constructed facilities, 17,000 persons for designing and manufacturing of the facilities and 3000 persons for other minor accessory activities. Domains of the renewable energy sources that would be represented are: biomass, biogas, hydro energy from small water courses, geothermal energy, wind energy and the unaccumulated sun energy. Productions of energy from biomass and biogas would be at most used in Vojvodina, so that it can be judged that at least 50–60% of the designed employments would be opened in Vojvodina. In other words, Vojvodina could expect till the year 2015 some 13,000 new employments in the domain of application of the renewable energy sources. These employments would include 8000 personalities on designing jobs, equipment production and uprising of plants, 3000 workers for the maintenance of newly constructed plants and 2000 employed for auxiliary activities. Other domains of renewable energy sources would be less used in Vojvodina, and according to estimations, some 1000 employments should be opened for them in Vojvodina, i.e. Vojvodina could expect some 14,000 new employments in the domain of renewable energy sources till the year 2015 (Table 3).

Table 3
Possibilities of energy production from biomass in Vojvodina; contemporary levels and forecast for the year 2020.

Biomass	Energy (GWh/m^2 year)			
	Contemporary state		Forecast for 2020	
	Electric	Thermal	Electric	Thermal
Agricultural plant residues	1.28	3	2.56	6
Vineyard residues	0.39	1	0.78	2
Fast growing forests	0.06	0.17	1.56	4.06
Processing by products	0.36	0.85	1.1	2.50
Liquid biomass	0	0	–	–
Biogas	0.20	0.08	0.4	0.16
Total	2.29	5.1	6.4	14.72

4. Conclusion

Biomass, as a clean and cost-effective fuel option, has tremendous potential for application in Vojvodina. Necessary know-how about most of the biomass energy technologies already exists. There is just a need to allocate necessary resources for improving these technologies and plan their widespread dissemination. Better coordination between existing institutions is required to avoid duplication of research.

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